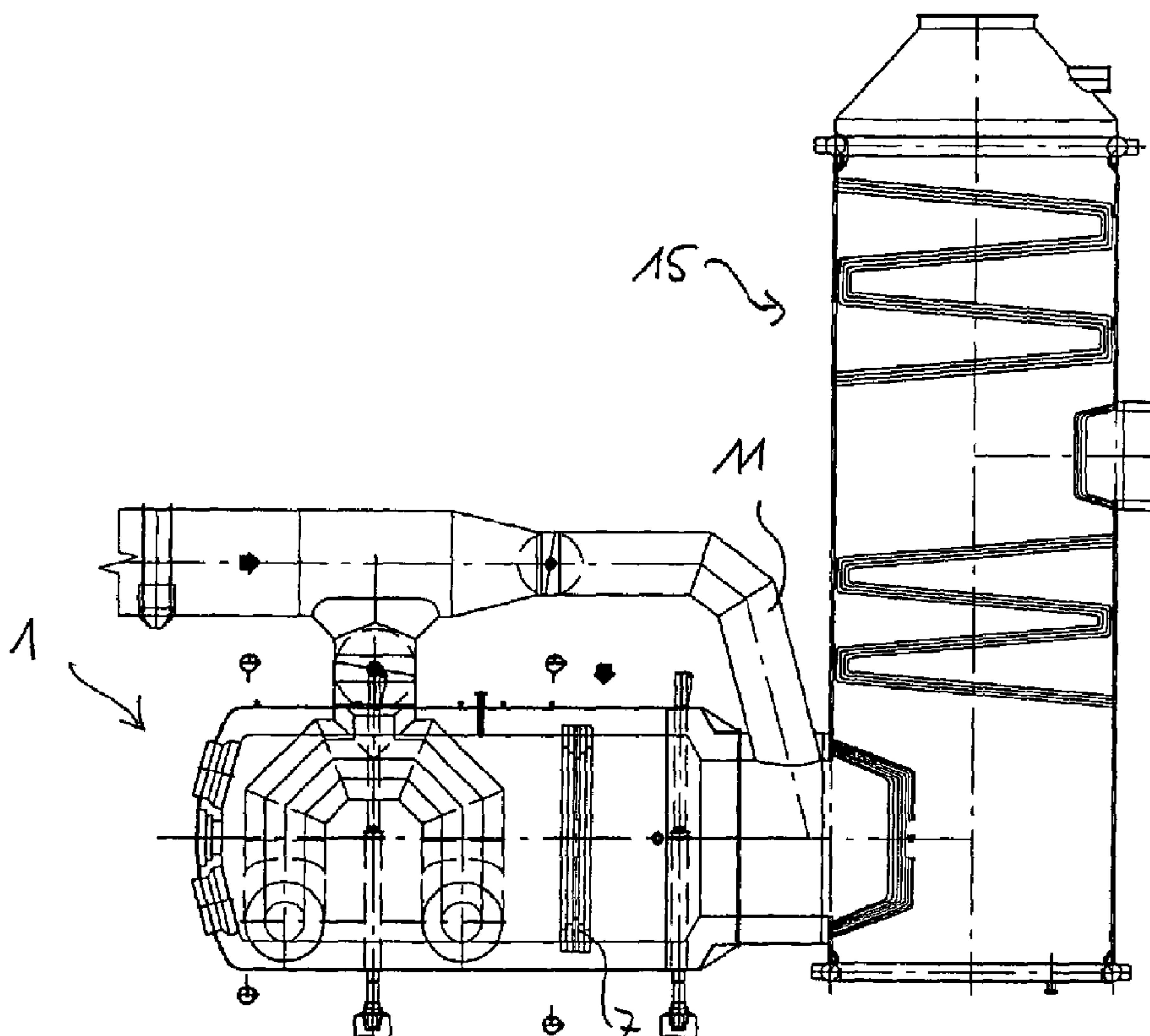




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(57) **Abrégé/Abstract:**

During the combustion of sulfur with air for producing sulfur dioxide, sulfur is burnt in a first portion of the combustion furnace under substoichiometric conditions. The sulfur dioxide formed in the first portion and unburnt sulfur are supplied to a second portion of the furnace adjoining the first portion, in that they are subjected to post-combustion with air. This provides for the production of sulfur-dioxide- containing gas free from nitrogen oxide.



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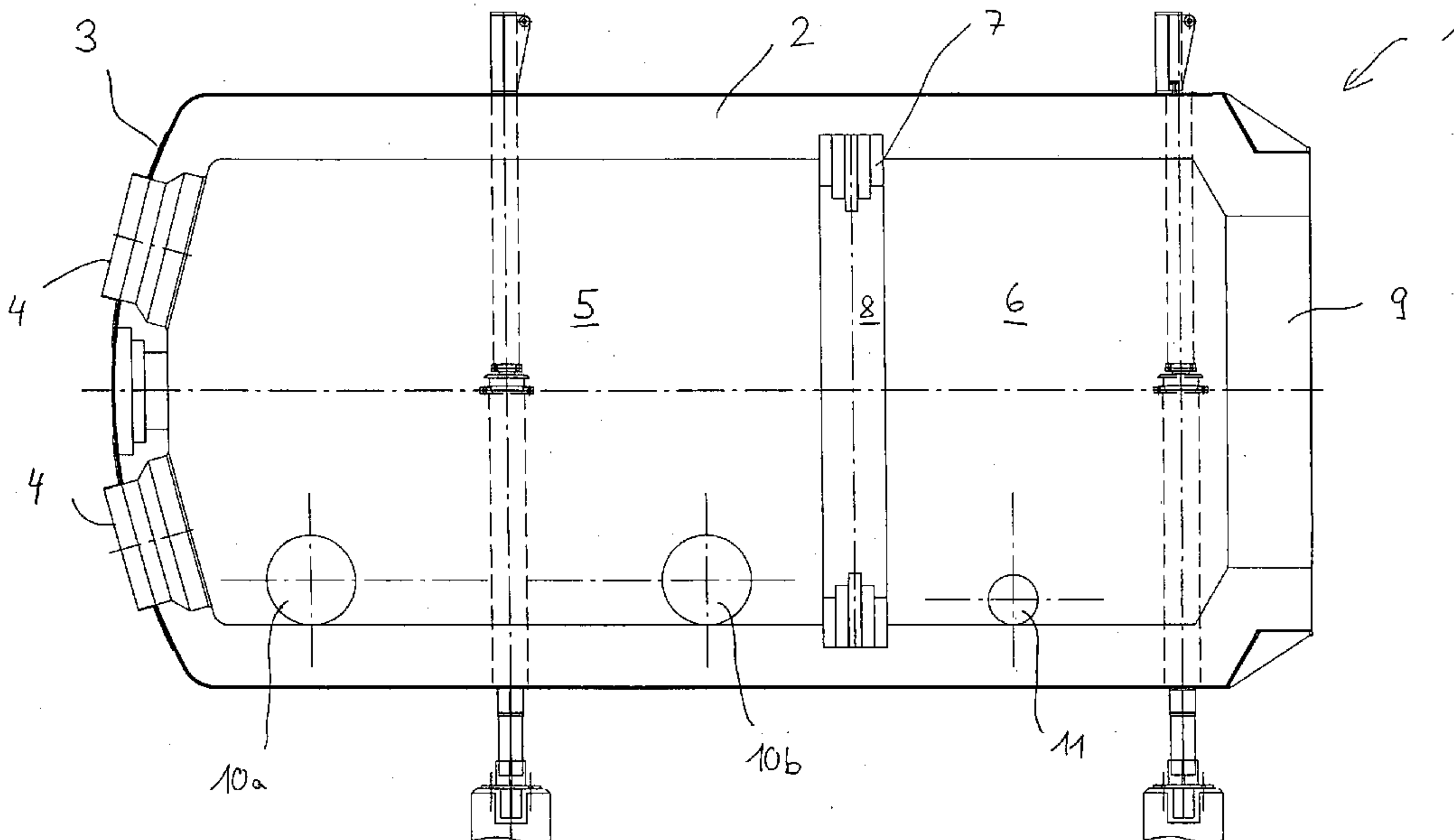
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(57) Abstract: During the combustion of sulfur with air for producing sulfur dioxide, sulfur is burnt in a first portion of the combustion furnace under substoichiometric conditions. The sulfur dioxide formed in the first portion and unburnt sulfur are supplied to a second portion of the furnace adjoining the first portion, in that they are subjected to post-combustion with air. This provides for the production of sulfur-dioxide-containing gas free from nitrogen oxide.

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## Process and Apparatus for the Combustion of Sulfur

### Background of the Invention

5 The present invention relates to a process for the combustion of sulfur with oxygen-containing gases, in particular air, for producing sulfur dioxide, wherein sulfur and combustion air are supplied to a furnace and wherein the sulfur is evaporated and subsequently oxidized in a first portion of the furnace under substoichiometric conditions, and to an apparatus for performing this process.

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Sulfur dioxide primarily is used for producing sulfuric acid or liquid sulfur trioxide and generally is produced by calcining / smelting sulfur-containing ores or by combustion of elementary sulfur. The combustion generally is effected with atmospheric air, but air enriched with oxygen or even pure oxygen are used as well. For cost reasons, however, the use of pure oxygen for the combustion of sulfur mostly is not expedient. Nowadays, sulfur itself is used almost exclusively in liquid form and in general is supplied as a liquid and stored temporarily. The liquid sulfur is supplied to the combustion furnace with temperatures of 140 to 150 °C, at which its viscosity is low enough to provide for injection via nozzles. In order to optimize the combustion, the liquid sulfur is atomized in the furnace and is thoroughly mixed with the combustion air.

15 The combustion of sulfur requires equal molar quantities of sulfur and oxygen. With ambient air, which contains 20.95 vol-% of O<sub>2</sub>, an SO<sub>2</sub> gas with a maximum of 20.5 vol-% of SO<sub>2</sub> can theoretically be obtained with a stoichiometric combustion of sulfur. To ensure a complete combustion of sulfur, an excess of air is usually supplied. Problems resulting from unburnt sulfur, which is condensed and deposited in colder parts of the plant, thus can be avoided. The hyperstoichiometric combustion is described for instance in Ullmann's Encyclopedia of Industrial  
25 Chemistry, 5<sup>th</sup> edition, 1994, vol. A25, p. 574 f. The combustion is effected in a horizontally arranged cylindrical furnace, which has a refractory lining and on its end face includes a centrally arranged system of burners. The liquid sulfur is atomized and mixed with the combustion air and burns at temperatures of 600 to 1,600 °C in dependence on the desired sulfur dioxide concentration. Subsequent to the  
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sulfur furnace, a waste heat boiler is provided, before the gas is supplied to a sulfuric acid contact plant. The converter of the contact plant generally employs initial concentrations of sulfur dioxide of 10 to 12 vol-%, which must possibly be adjusted by means of further equipment.

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EP 0 762 990 B1 also describes the hyperstoichiometric combustion of sulfur.

A method and an apparatus for the combustion of liquid sulfur into sulfur dioxide in a burner furnace is described in US 3,879,530. The liquid sulfur and the primary combustion-supporting air are injected concurrently in a first part of the combustion furnace. A secondary combustion-supporting gas is introduced further downstream of the furnace in the combustion chamber prior to the outlet of the burned gases containing sulfur dioxide into an adjoining boiler.

15 At combustion temperatures above 1,100 °C, the formation of nitrogen oxides (NO<sub>x</sub>) is strongly increasing, even if less free oxygen is available for the formation of nitrogen oxides due to the higher sulfur dioxide concentration. Only above a sulfur dioxide concentration of 18 vol-%, the formation of NO<sub>x</sub> is decreasing again due to the lack of oxygen. The formation of nitrogen oxides therefore limits the preheating of the combustion gases in conventional sulfur combustion systems, as the combustion temperature is increasing. This impairs the economy of the plants.

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For producing gases with high sulfur dioxide concentrations and very low NO<sub>x</sub> content, a two-stage plant was proposed for instance in DE 1 948 754, in which the elementary sulfur first was burnt under substoichiometric conditions (oxygen debt). Upon passing through a heat exchanger, the produced gases containing sulfur dioxide and sulfur were then subjected to post-combustion with oxygen-containing gases in a further apparatus at about 1000 °C. In terms of plant construction, however, this multistage installation is quite complex and hence expensive.

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- 2a -

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### Description of the Invention

5 It is the object underlying the invention to produce gases with a high sulfur dioxide concentration with simple means and at the same time largely minimize the formation of nitrogen oxides (NO<sub>x</sub>).

10 This object substantially is solved with the invention in that in a process as mentioned above the sulfur dioxide formed in the first portion of the sulfur combustion furnace and unburnt sulfur are supplied to a second portion of the furnace adjoining the first portion and are subjected to post-combustion with oxygen-containing

gases, in particular air, in the outlet of the second portion of the furnace or in the inlet portion of the waste heat boiler (heat recovery system).

More particularly, the present invention is directed to a process for the combustion of sulfur with oxygen-containing gases for producing sulfur dioxide, the process comprising the steps of:

- introducing sulfur and the oxygen-containing gases to a furnace;
- evaporating the sulfur and subsequently oxidizing a portion of the sulfur to sulfur dioxide under sub-stoichiometric conditions in a first portion of the furnace;
- introducing the sulfur dioxide formed in the first portion and unoxidized sulfur to a second portion of the furnace adjoining the first portion; and
- subjecting the sulfur dioxide and the unoxidized sulfur to post-combustion with oxygen-containing gases in an inlet of a downstream waste heat boiler.

Thus, like in DE 1 948 754, there is first effected a substoichiometric combustion of sulfur and then a post-combustion at the outlet of the second chamber or in the inlet portion of the waste heat boiler. In accordance with the invention, however, this second chamber is provided directly subsequent to the first combustion chamber of the sulfur furnace. An interposed heat exchanger, by means of which the gas temperature is decreased in DE 1 948 754, can be omitted. Nevertheless, the formation of nitrogen oxides is minimized, as due to the rapid cooling in the waste heat boiler the retention time at high temperatures is too low for the formation of significant amounts of nitrogen oxides. In the first portion of the furnace, the formation of  $\text{NO}_x$  is excluded as a result of the lack of oxygen. In the second portion this is effected by the immediate rapid cooling of the gas in the waste heat boiler.

As it is particularly important in the substoichiometric combustion in the first portion of the furnace that the gases are mixed with the sulfur very well, so that the oxygen can be consumed completely and no nitrogen oxides can be formed, it is pro-

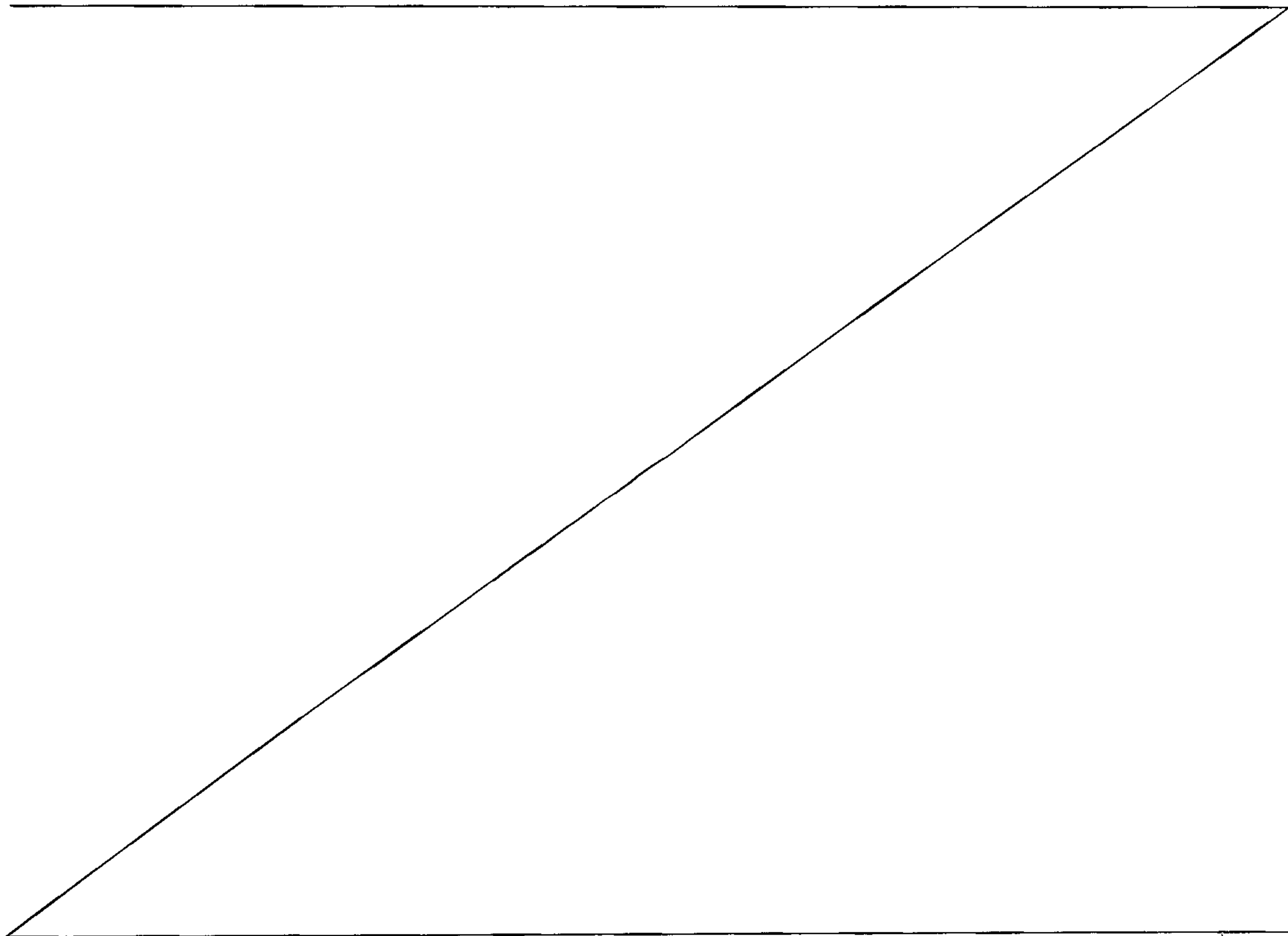
3a

vided in accordance with a preferred aspect of the invention that the combustion air is introduced into the furnace tangentially. This promotes turbulence in the combustion chambers and hence the thorough mixing of the gases. The gas stream then passes through the furnace spirally and in an axial direction thereof.

In accordance with the invention, the oxygen-containing gases can be introduced into the first and second portions of the furnace with a parallel sense of rotation. Alternatively, however, it is also possible to introduce the gases into the second chamber of the furnace with the opposite sense of rotation. Expediently, this is effected in that the combustion air supply duct extending into the second furnace chamber opens at the furnace wall opposite the supply duct extending into the first furnace chamber.

In accordance with the invention, the sulfur dioxide concentration obtained in the first and second portions of the furnace is adjusted by controlling the amount of air and/or sulfur supplied. The volume flow rates preferably are chosen such that in

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- 4 -

the first portion of the furnace a sulfur dioxide concentration of about 20 to 21 vol-%, preferably about 20.5 vol-% is obtained. Above a sulfur dioxide concentration of 18 vol-%, the formation of nitrogen oxides decreases rapidly due to the low content of free oxygen, while it is hardly influenced by the retention time.

5

In accordance with the invention, sufficient oxygen is supplied in the second portion of the furnace by means of oxygen containing gases so that a sulfur dioxide concentration of 6 to 95%, preferably 9 to 35 vol-%, and in particular about 12 to 18 vol-% is obtained at the end of the combustion. If a sulfur dioxide concentration of 12 vol-% is adjusted, the sulfur dioxide obtained can directly be supplied to a contact boiler of the sulfuric acid plant. If a sulfuric acid concentration of 18 vol-% is chosen, it is ensured that all the sulfur is consumed, and a deposition in succeeding parts of the plant is excluded. Due to the substantially higher inlet temperature of the waste heat boiler (1,600 °C instead of 1,150 °C), the heat recovery system requires a smaller heat-exchange surface, so that the capital costs are reduced. Behind the waste heat boiler, the SO<sub>2</sub> concentration is reduced by supplying air, the concentration to be adjusted depending on the succeeding equipment.

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In the first portion of the furnace, the combustion of sulfur preferably is effected at about 1,000 to 1,800 °C, whereas the post-combustion at the outlet of the second portion of the furnace or at the inlet of the waste heat boiler begins at about 1,000 to 1,800 °C. Upon inlet into the waste heat boiler an immediate rapid cooling of the supplied gases is effected. A combustion temperature of about 1,000 °C at the start of the post-combustion in the second portion is chosen in particular when a sulfur dioxide concentration of 12 vol-% is desired, whereas with a sulfur dioxide concentration of 18 vol-% a combustion temperature of about 1,600 °C is set for the start of the post-combustion in the second portion. These temperatures are based on a combustion air inlet temperature of about 100 °C. The temperature will vary accordingly with varying air temperature. In any case, due to the low concentration of the unburnt sulfur (sulfur vapor) in the outlet of the second chamber of the furnace and due to the short retention time in the second chamber of the furnace, a combustion temperature can be chosen, such that due to the immediate cooling in the waste heat boiler the formation of nitrogen oxides is minimized. The retention time before the cooling below 1,000 °C is not sufficient to form a signifi-

- 5 -

cant amount of NO<sub>x</sub>. The retention time in the second portion of the furnace is less than 0.5 s, preferably less than 0.3 s. In the waste heat boiler as fast as possible a cooling below 800 °C, preferably below 700 °C, and most preferably below 600 °C is effected. The retention time until a temperature of about 1,000 °C is reached is  
5 less than 1 s, preferably less than 0.7 s.

To promote the thorough mixing of sulfur with the combustion gases, the sulfur preferably is introduced into the first portion of the furnace in liquid form and is atomized by means of air when entering the furnace. In accordance with the inven-  
10 tion, this can be effected by means of rotary atomizers, ultrasonic atomizers, or by supplying sulfur through lances.

An increased turbulence and hence an even better mixing of the gases in the first portion of the furnace is achieved in a development of the invention in that the  
15 stream of air supplied to the first portion of the furnace is supplied to the furnace at one or more, in particular two positions located one behind the other in axial direction of the furnace.

The invention also applies to an apparatus for the combustion of sulfur, comprising  
20 a furnace at the end face of which a system of burners is provided, and comprising ducts for supplying sulfur as well as oxygen-containing gases, in particular air, wherein the furnace includes a first portion and an adjoining second portion, to each of which oxygen-containing gases are supplied for the combustion of sulfur.

25 The ducts for supplying the combustion air preferably tangentially open into the first and second portions, in order to support the thorough mixing of sulfur and combustion air by means of turbulences.

30 In the ducts for supplying combustion air to the first and second portions, control valves for adjusting the volume flow rates to be supplied are provided in accordance with the invention. Thereby, the ratio of the volume flow rates supplied to the individual chambers can also be controlled.

- 6 -

In accordance with a particularly preferred aspect of the invention, the first and second portions are separated from each other by an orifice. The orifice supports the turbulence when the gas leaving the first portion enters the second portion and nevertheless provides a certain separation of the regions, so that the concentrations can be adjusted selectively. In an alternative preferred embodiment, however, the orifice can also be omitted, the delimitation of the furnace chambers then being effected by controlling the streams of air supplied to the portions.

Developments, advantages and possible applications of the invention can also be taken from the following description of embodiments and the drawing. All features described and/or illustrated in the drawing form the subject-matter of the invention per se or in any combination, independent of their inclusion in the claims or their back-reference.

#### 15 **Brief Description of the Drawings**

- Fig. 1 schematically shows a section through a sulfur combustion furnace in accordance with a first embodiment of the invention with an orifice,
- 20 Fig. 2a schematically shows the furnace of Fig. 1 with an illustration of the supply system for the combustion air,
- Fig. 2b shows a view of the furnace with burner openings,
- 25 Fig. 3a schematically shows a sulfur combustion furnace in accordance with a second embodiment of the invention without an orifice,
- Fig. 3b shows a view of the furnace with burner openings,
- 30 Fig. 4a schematically shows a sulfur combustion furnace in accordance with a third embodiment of the invention with an orifice
- Fig. 4b shows a view of the furnace with burner openings,

- 7 -

- Fig. 4c shows a view of the furnace with burner openings and a gas supply to the second chamber,
- 5 Fig. 5a schematically shows a sulfur combustion furnace in accordance with a fourth embodiment of the invention without an orifice,
- Fig. 5b shows a view of the furnace with burner openings,
- 10 Fig. 5c shows a view of the furnace with burner openings and a gas supply to the second chamber,
- Fig. 6 shows a sectional view of the furnace similar to Fig. 1 with a downstream waste heat boiler,
- 15 Fig. 7 shows a view of the furnace with the waste heat boiler wherein the combustion air is introduced into the inlet portion of the waste heat boiler,
- 20 Fig. 8 shows a view of the furnace with the waste heat boiler wherein the combustion air is introduced into the inlet portion of the waste heat boiler and wherein the furnace does not comprise an orifice,
- Fig. 9 shows the flow diagram of the process of the invention in accordance with Example 1, and
- 25 Fig. 10 shows the flow diagram of the process of the invention in accordance with Example 2.

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### Description of the Preferred Embodiments

Fig. 1 schematically shows a furnace 1 for the combustion of sulfur for producing sulfur dioxide in accordance with a first embodiment of the present invention. The furnace 1 has a furnace wall 2 with a refractory lining and is designed as a cylin-

- 8 -

drical furnace arranged horizontally. With a confined space, however, the furnace can also be arranged vertically.

5 In the end wall 3 of the furnace 1, one or more non-illustrated atomizers 4 are provided, by means of which liquid sulfur, which is supplied via a non-illustrated duct, is atomized to form small droplets which are mixed with the combustion gases in the furnace, are evaporated and burnt (oxidized). The atomizers 4 can constitute rotary atomizers, for instance in the form of the Luro burner developed by Lurgi, as it is illustrated in Ullmann's Encyclopedia of Industrial Chemistry, 5<sup>th</sup> edition 1994,  
10 vol. A25, p. 575.

Alternatively, the atomizer can constitute an ultrasonic atomizer, pressure atomizer or binary burner, as they are used conventionally in the combustion of sulfur for finely atomizing the sulfur and thoroughly mixing the same with the combustion air.  
15 In the illustrated embodiment, two atomizers 4 are provided in the end wall 3 of the furnace 1, but it is also possible to provide merely one centrally arranged atomizer 4 or three or more atomizers distributed around the center of the end wall 3.

The interior of the furnace 1 is divided into a first portion 5 (front chamber) and a  
20 second portion 6 (post-combustion chamber). Generally, the volume of the second portion 6 is about one third or less of the volume of the furnace 1, but the invention is not limited thereto. In the illustrated embodiment, an orifice (weir) 7 is provided between the portions 5, 6, which separates the portions 5, 6 from each other, but includes a large enough passage 8, through which the gas mixture can pass from  
25 the first portion 5 into the second portion 6. The diameter of the passage 8 is for instance about 80% of the inside diameter of the furnace in the first or second portion 5, 6. Via an outlet opening 9, the furnace 1 is connected with a waste heat boiler (not shown in Fig. 1) or some other equipment, through which the gas mixture containing sulfur dioxide is supplied for instance to a contact plant for the pro-  
30 duction of sulfuric acid.

Supply ducts 10a, 10b, through which combustion air is supplied, open into the first portion 5. A supply duct 11, likewise for supplying combustion air, opens into the second portion 6. Each of the supply ducts 10a, 10b and 11 tangentially opens

- 9 -

into the first portion 5 and into the second portion 6, respectively, the supply duct 11 for the second portion 6 opening into the furnace 1 at the furnace wall opposite the supply ducts 10a, 10b, as can in particular be seen in Fig. 2b. The supply ducts 10a, 10b and 11 together are supplied with combustion air via a common supply tube 12, the volume flow entering the furnace each being controlled via control valves 13 and 14, which are each provided in the supply ducts 10, 11. The supply ducts 10a, 10b branch out behind the control valve 13, so that substantially the same volume flow is supplied to each of them and introduced into the first portion 5 of the furnace 1 at points located axially one behind the other.

10

The sulfur combustion furnace 1 in accordance with the first embodiment of the present invention substantially is designed as described above. Its operation will be explained below.

15

Liquid sulfur is supplied to the furnace 1 via the atomizers 4 with a temperature of e.g. 140 to 150 °C and is atomized with primary air. Via the supply openings 10a, 10b, e.g. dry ambient air is tangentially introduced into the first portion 5. The air should provide the oxygen necessary for combustion. Instead of ambient air, air enriched with oxygen or even pure oxygen can of course be used as well, as far as this is economically reasonable. When the present application makes reference to air which is introduced into the furnace, all oxygen-containing gases therefore are covered in principle.

20

Since the stream of sulfur is supplied in axial direction and, when using a rotary atomizer, additionally includes a radial component, the sulfur and the tangentially supplied combustion air are mixed very well and spirally move in axial direction of the furnace 1.

25

Via the supply ducts 10a, 10b, ambient air is supplied in such an amount that in the first portion 5 a slight substoichiometric condition (oxygen debt) is obtained, preferably in a molar ratio  $O_2:S$  of 0.95 to 0.99. As a result, the sulfur reacts with all the oxygen available, so that even at the high temperatures of 1600 to 1800 °C, which exist during the combustion, no nitrogen oxides ( $NO_x$ ) will be formed.

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- 10 -

In the first portion 5, a gas containing sulfur dioxide is obtained with a sulfur dioxide concentration of about 20.5 vol-%. Together with the still unburnt sulfur (sulfur vapor), this gas flows through the passage 8 into the second portion 6, in which a sufficient amount of dried ambient air is supplied through the supply duct 11 before leaving the second portion 6 through the outlet opening 9, in order to completely convert the remaining sulfur vapor into sulfur dioxide. The total retention time of the gas in the furnace 1 is less than 2 s, preferably less than 1 s and in particular less than 0.8 s.

Fig. 6 shows that downstream of the furnace 1 a waste heat boiler 15 is provided directly adjacent to the second portion 6 of furnace 1. The gas exiting the second portion 6 enters the waste heat boiler 15 where it is cooled while heating water flowing through ducts 16 to create high pressure steam in a standard heat recovery system. The cooled gas stream then exits the waste heat boiler 15 through openings 17 and, optionally, 18 to be supplied to the contact boiler of a sulfuric acid plant or other suitable equipment.

As the waste heat boiler is provided directly downstream of the furnace 1 the temperature of the gas stream will drop rapidly below 1,000 °C due to the heat radiation in the waste heat boiler 15 which has wall temperatures in the range of about 300 to 350 °C. Due to the low retention time of the gas stream in the second portion 6 of the furnace 1 at a temperature above 1,000 °C the formation of considerable amounts of nitrogen oxides is suppressed. A temperature of below 1,000 °C should be reached in the waste heat boiler in less than 0.5 s.

The resulting sulfur dioxide concentration can be adjusted in dependence on the equipment succeeding the furnace 1. In the case of a combustion at about 1,000 °C in the second portion 6, the sulfur dioxide concentration can for instance be adjusted to about 12 vol-%, so that the gas flowing out already has a concentration suitable for the contact boiler of the sulfuric acid plant. Due to the low combustion temperature and the simultaneous cooling in the subsequent waste heat boiler, the formation of nitrogen oxides is minimized.

- 11 -

In the case of a beginning post-combustion in the outlet of the second portion with temperatures of about 1,600 °C, a gas concentration of about 18 vol-% of sulfur dioxide in the furnace exhaust gas can be achieved, whereby it is ensured that in the waste heat boiler 15 all the sulfur has been consumed. Behind the waste heat boiler 15, a sulfur dioxide concentration suitable for the sulfuric acid plant can be adjusted by additionally supplying air.

In Figures 3 to 5, further embodiments of the present invention are shown. The operation of these embodiments substantially corresponds to the embodiment as shown in Figures 1 and 2, so that in so far reference is made to the above description. In addition, the same reference numerals are used for the same components, and subsequently merely the differences of these embodiments with respect to the first embodiment as shown in Figures 1 and 2 will be explained.

Figures 3a and 3b show an embodiment without the orifice 7 provided in the first embodiment. The first portion 5 and the second portion 6 are defined by the control of the supply of combustion air by means of the control valves 13, 14. The remaining operation of the second embodiment corresponds to that of the first embodiment.

Figures 4a to 4c show a third embodiment of the invention, the supply of combustion air being effected via the supply ducts 10a, 10b, 11 to the first and second portions 5, 6, respectively, but not via the opposed side walls of the furnace 1. Rather, the supply ducts 10a, 10b and 11 each open on the same side of the furnace 1, so that the stream of air entering the furnace tangentially, which spirally moves forward in axial direction of the furnace 1, extends in the first and second portions 5, 6 with a parallel direction of rotation. For the rest, the third embodiment corresponds to the first embodiment.

In the fourth embodiment of the invention as shown in Figures 5a to 5c, the combustion air is introduced into the first and second portions 5, 6, respectively, on the same side of the furnace 1 similar to the third embodiment. However, similar to the second embodiment, the furnace 1 does not include the orifice 7 provided in the

- 12 -

first and third embodiments. For the rest, the fourth embodiment as shown in Figures 5a to 5c also corresponds to the embodiments described above.

5 In a preferred embodiment as shown in Fig. 7, the combustion air is entered directly into the inlet portion of the waste heat boiler 15 via the duct 11. Thereby, the retention time of the gas stream at a temperature of above 1,000 °C is even further reduced and consequently the formation of nitrogen oxides is additionally suppressed. As in the embodiments of Fig. 1 and 4, the furnace 1 may comprise an orifice 7 between the first and second portions 5, 6 (Fig. 7). Alternatively, the portions 5, 6 are not separated by an orifice (Fig. 8), similar to the embodiments of 10 Fig. 3 and 5.

As a result of the two-stage configuration of the combustion of sulfur with a sub-stoichiometric combustion in the first portion 5 and a subsequent beginning post-combustion in the outlet of the second portion 6 (or even in the inlet portion of the waste heat boiler 15 only) of the sulfur not yet burnt in the first portion 5, a gas with a high sulfur dioxide concentration will be achieved by means of the invention, the formation of nitrogen oxides largely being avoided by the immediate cooling in the waste heat boiler and thus an insufficient retention time at high temperatures.

20

### Example 1

Fig. 9 shows a flow diagram of the process of the invention, by means of which a gas containing sulfur dioxide with a concentration of 12 vol-% of sulfur dioxide can be obtained. For the process, each of the first to fourth embodiments of a sulfur combustion furnace described with reference to Figures 1 to 5 can be used.

25

To the combustion furnace 1, 60.04 t/h of sulfur were supplied, which were introduced into the furnace in atomized form by means of 14,030 Nm<sup>3</sup>/h of primary air with a temperature of 120 °C. Into the first portion 5 of the furnace, 175,000 Nm<sup>3</sup>/h of ambient air with a temperature of 120 °C were charged, whereas to the second portion 6 of the furnace 152,518 Nm<sup>3</sup>/h of ambient air with a temperature of 120 °C were supplied. The total retention time in the furnace 1 was less than 0.6 s, in the second portion less than 0.2 s.

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- 13 -

In the first portion 5, a sulfur dioxide concentration of 20.5% was obtained with a combustion temperature of 1,700 to 1,800 °C, whereas in the outlet of the second portion 6 or in the inlet of the waste heat boiler 15 a sulfur dioxide concentration of 12 vol-% was achieved, which corresponds to the initial concentration of the converter of the sulfuric acid plant, so that the furnace exhaust gas can directly be supplied to the sulfuric acid plant upon adjustment of the desired temperature. Due to the low retention time of less than 0.2 s in the second portion 9 of the furnace and the rapid cooling to about 500 °C in the waste heat boiler the formation of nitrogen oxides can be efficiently avoided.

### Example 2

In the flow diagram of a second experiment, which is shown in Fig. 10, the conditions in the first portion 5 of the furnace 1 correspond to those of the first example. However, the supply of combustion air in the outlet of the second portion 6 was reduced to 38,669 Nm<sup>3</sup>/h, so that a sulfur dioxide concentration of 18% was obtained at the outlet of portion 6. This ensures that all the sulfur vapor, which has passed from the first portion 5 into the second portion 6, is consumed in the outlet of the second portion 6 or in the inlet of the waste heat boiler 15. The temperature of the gas stream when entering the waste heat boiler 15 is about 1,600 °C. In the waste heat boiler 15 the temperature drops rapidly and a temperature of less than 1,000 °C is reached in less than 0.5 s. Accordingly, the retention time at high temperatures is too short as to form significant amounts of nitrogen oxides.

As a sulfur dioxide concentration of 18 vol-% is not suitable for entrance into a conventional sulfuric acid contact plant, the sulfur dioxide concentration is decreased again to 12 vol-% by adding for instance 113,849 Nm<sup>3</sup>/h of ambient air with a temperature of 120 °C. This gas mixture can then be supplied to the sulfur contact plant.

**List of Reference Numerals**

	1	furnace
	2	furnace wall
5	3	end wall
	4	atomizer
	5	first portion
	6	second portion
	7	orifice
10	8	passage
	9	outlet opening
	10a, 10b	supply duct
	11	supply duct
	12	supply tube
15	13	control valve
	14	control valve
	15	waste heat boiler
	16	ducts
	17	opening
20	18	opening

**CLAIMS**

1. A process for the combustion of sulfur with oxygen-containing gases for producing sulfur dioxide, the process comprising the steps of:

- introducing sulfur and the oxygen-containing gases to a furnace;
- evaporating the sulfur and subsequently oxidizing a portion of the sulfur to sulfur dioxide under sub-stoichiometric conditions in a first portion of the furnace;
- introducing the sulfur dioxide formed in the first portion and unoxidized sulfur to a second portion of the furnace adjoining the first portion; and
- subjecting the sulfur dioxide and the unoxidized sulfur to post-combustion with oxygen-containing gases in an inlet of a downstream waste heat boiler.

2. The process as claimed in claim 1, wherein the oxygen-containing gases are introduced into a region of an outlet of the second portion of the furnace.

3. The process as claimed in claim 1, wherein the oxygen-containing gases are introduced into the first and second portions of the furnace tangentially.

4. The process as claimed in claim 3, wherein the oxygen-containing gases are introduced into the first and second portions of the furnace in parallel.

5. The process as claimed in claim 3, wherein the oxygen-containing gases are introduced into the first and second portions of the furnace in opposite directions.

6. The process as claimed in any one of claims 1 to 5, wherein the oxygen-containing gases are introduced directly into the inlet of the waste heat boiler.

7. The process as claimed in any one of claims 1 to 6, further comprising:

- controlling an amount of at least one of the oxygen-containing gases and the sulfur to adjust a sulfur dioxide concentration in at least one of the first and second portions of the furnace.

8. The process as claimed in any one of claims 1 to 7, wherein a sulfur dioxide concentration of about 20 to 21 vol-% is obtained in the first portion of the furnace.

9. The process as claimed in any one of claims 1 to 8, wherein a sulfur dioxide concentration of 6 to 95 vol-% is obtained in the second portion of the furnace.

10. The process according to claim 9, wherein the sulfur dioxide concentration obtained in the second portion of the furnace is 9 to 35 vol-%.

11. The process as claimed in any one of claims 1 to 10, further comprising:

- establishing the combustion in the first portion of the furnace at 1,000 to 1,800°C.

12. The process as claimed in any one of claims 1 to 11, further comprising:

- establishing the combustion in the second portion of the furnace at 1,000 to 1,800°C.

13. The process as claimed in any one of claims 1 to 12, wherein the sulfur is introduced to the first portion of the furnace in liquid form and is atomized by the oxygen-containing gases when entering the furnace.

14. The process as claimed in any one of claims 1 to 13, wherein the oxygen-containing gases is introduced to the first portion of the furnace at one or more positions located one behind the other in axial direction of the furnace.

15. The process as claimed in any one of claims 1 to 14, wherein the oxygen-containing gases is air.

16. An apparatus for the combustion of sulfur, comprising:

- a furnace (1) having an end face provided with a system of burners, and
- ducts (10a, 10b, 11) for supplying sulfur as well as oxygen-containing gases to the furnace,

the furnace (1) including a first portion and an adjoining second portion (5, 6) each being for receiving the oxygen-containing gases for the combustion of sulfur and the apparatus further comprising a waste heat boiler (15) downstream of the furnace, having an inlet for receiving the oxygen-containing gases.

17. The apparatus as claimed in claim 16, wherein the second portion (6) of the furnace has an outlet region (9) for receiving the oxygen-containing gases.

18. The apparatus as claimed in any one of claim 16 or 17, wherein the ducts (10a, 10b, 11) for supplying the oxygen-containing gases open into the first and second portions (5, 6) tangentially.

19. The apparatus as claimed in any one of claims 16 to 18, wherein the ducts (10a, 10b, 11) for supplying the oxygen-containing gases to the first and second portions (5, 6) open into the furnace (1) on opposite sides.

20. The apparatus as claimed in any one of claims 16 to 19, wherein the duct (10a, 10b) for supplying the oxygen-containing gases to the first portion (5) opens into the furnace (1) on the same side as the duct (11) for supplying the oxygen-containing gases to the second portion (6).

21. The apparatus as claimed in any one of claims 16 to 20, comprising control valves in the ducts (10a, 10b, 11) for supplying the oxygen-containing gases to the first and second portions for adjusting volume flow rates to be supplied.

22. The apparatus as claimed in any one of claims 16 to 21, wherein the first and second portions (5, 6) are separated from each other by an orifice (7).

23. The apparatus as claimed in any one of claims 16 to 22, comprising an atomizer (4) for introducing the sulfur into the first portion (5).

24. The apparatus as claimed in claim 23, wherein the atomizer is a rotary or ultrasonic atomizer.

25. The apparatus as claimed in any one of claims 16 to 24, wherein the furnace is horizontally aligned.

26. The apparatus as claimed in any one of claims 16 to 25, wherein the oxygen-containing gases is air.

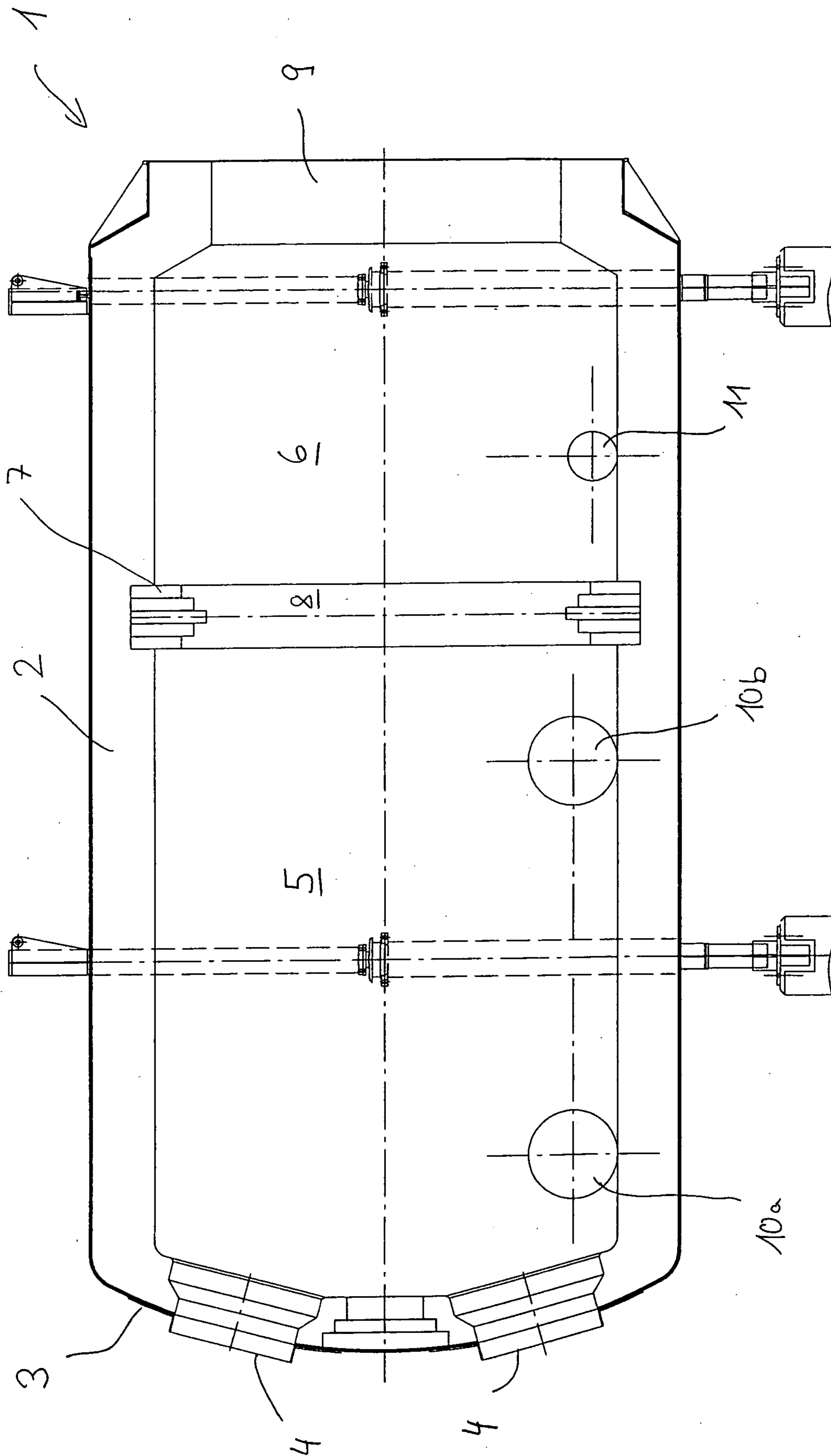


Fig. 1

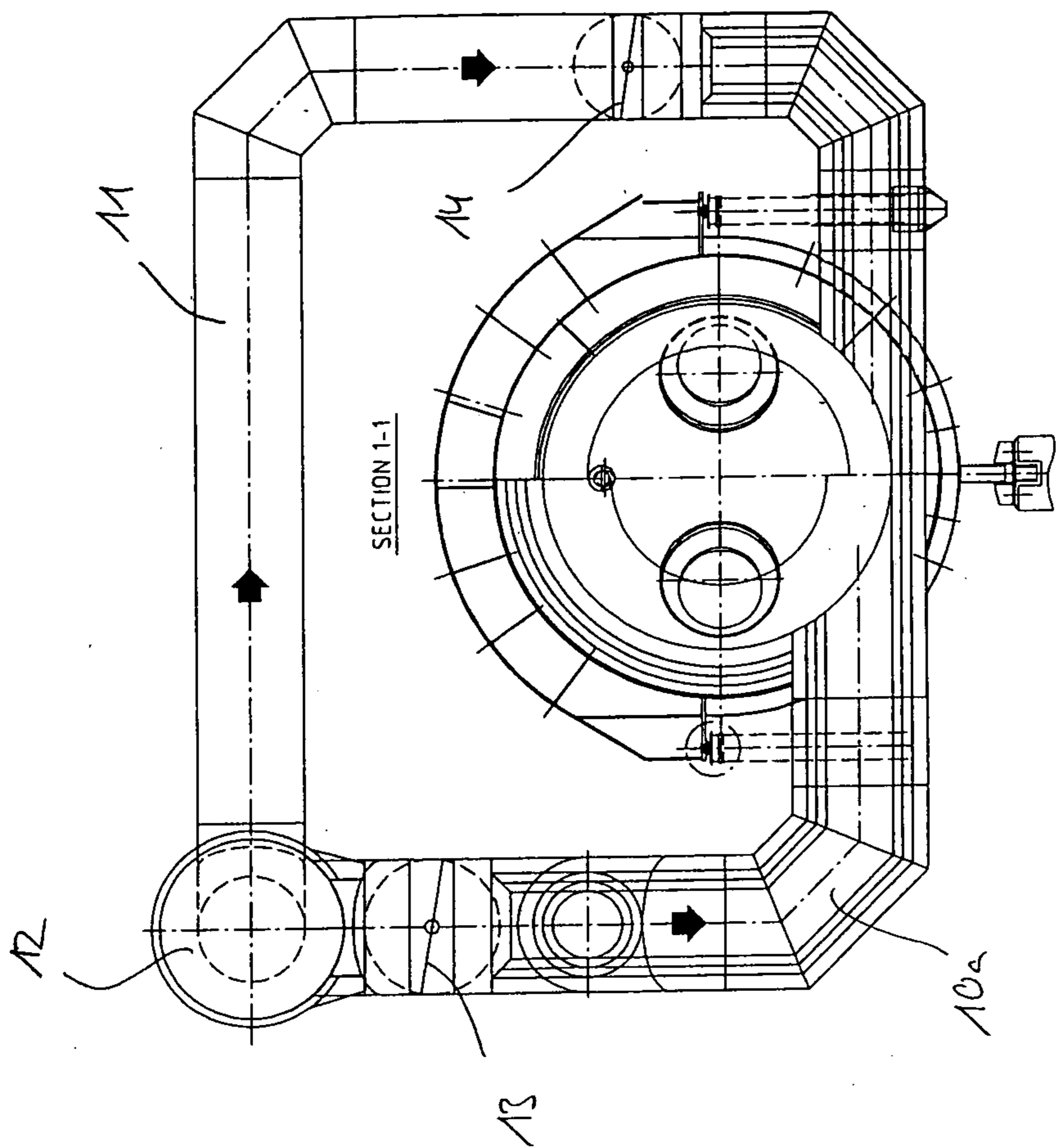


Fig. 2a

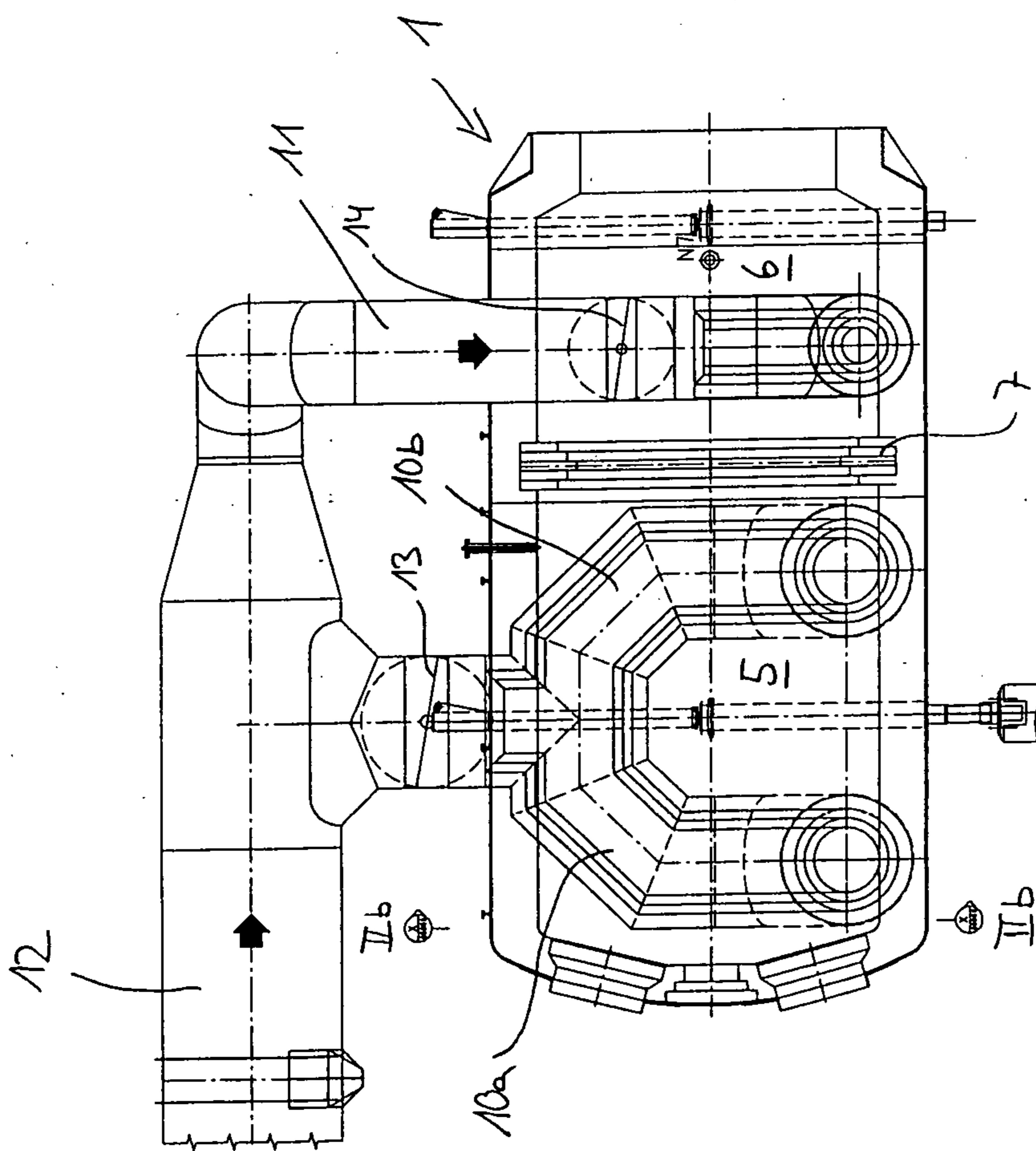


Fig. 2b

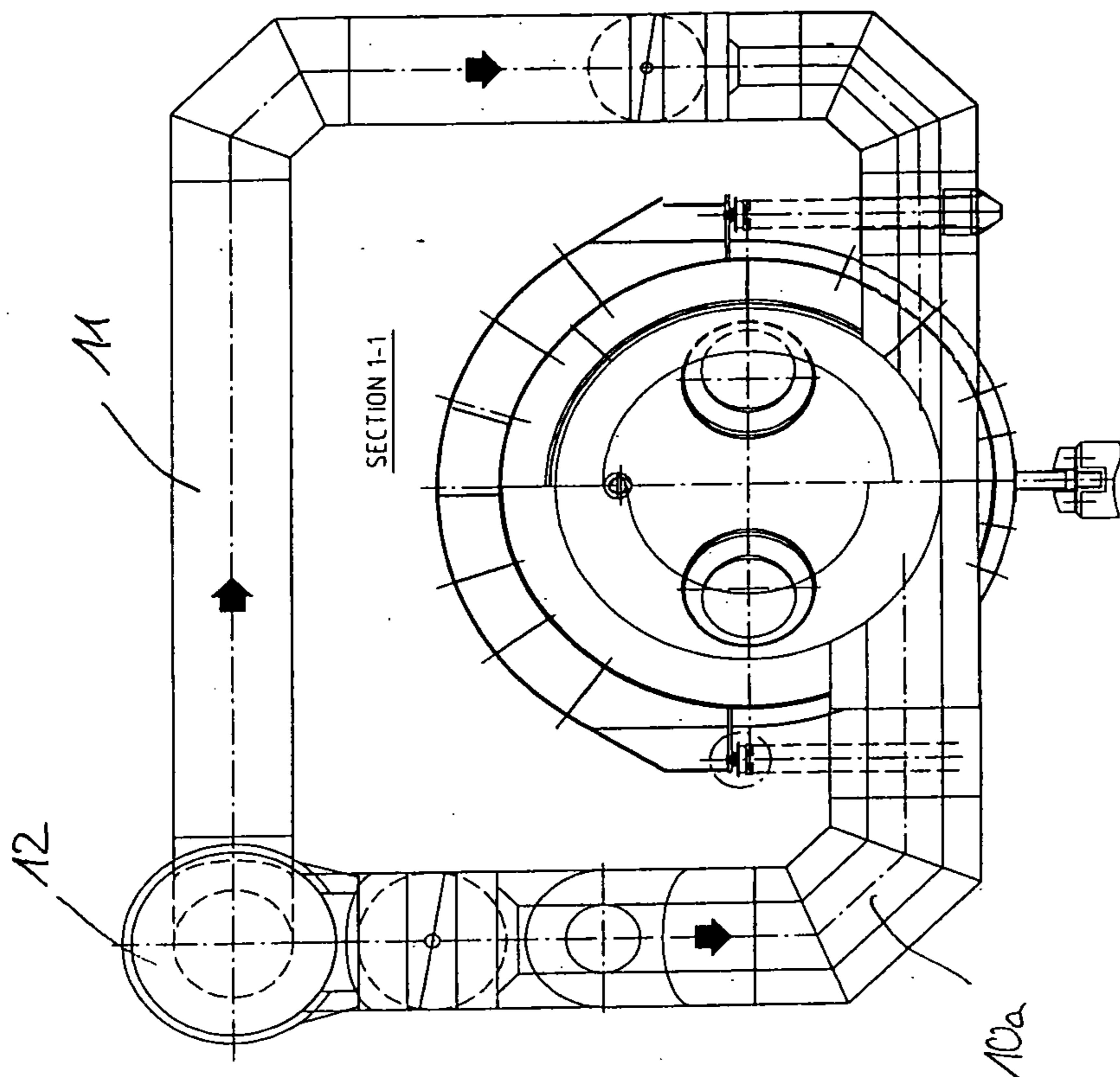


Fig 3b

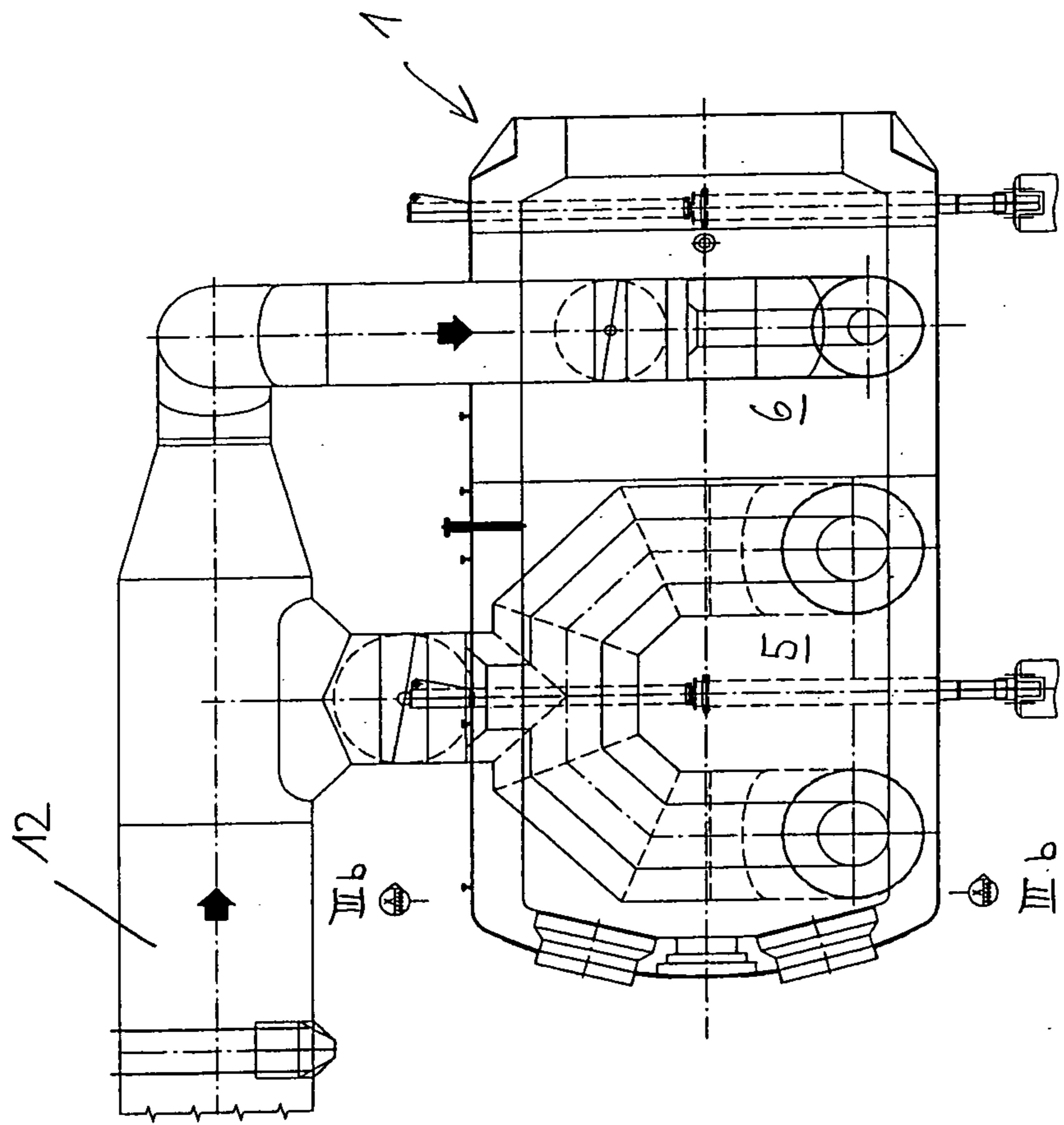


Fig. 3a

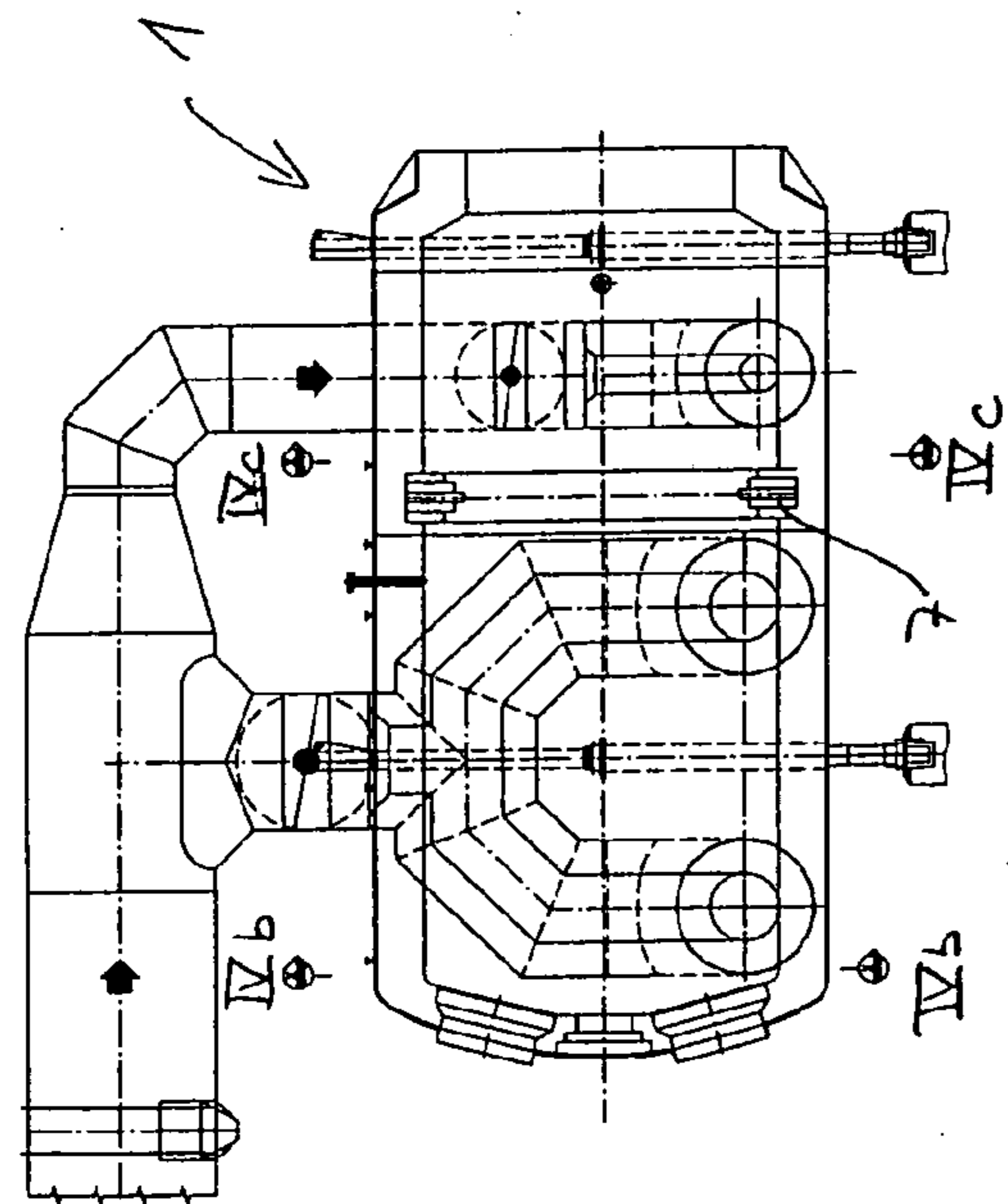


Fig. 4a

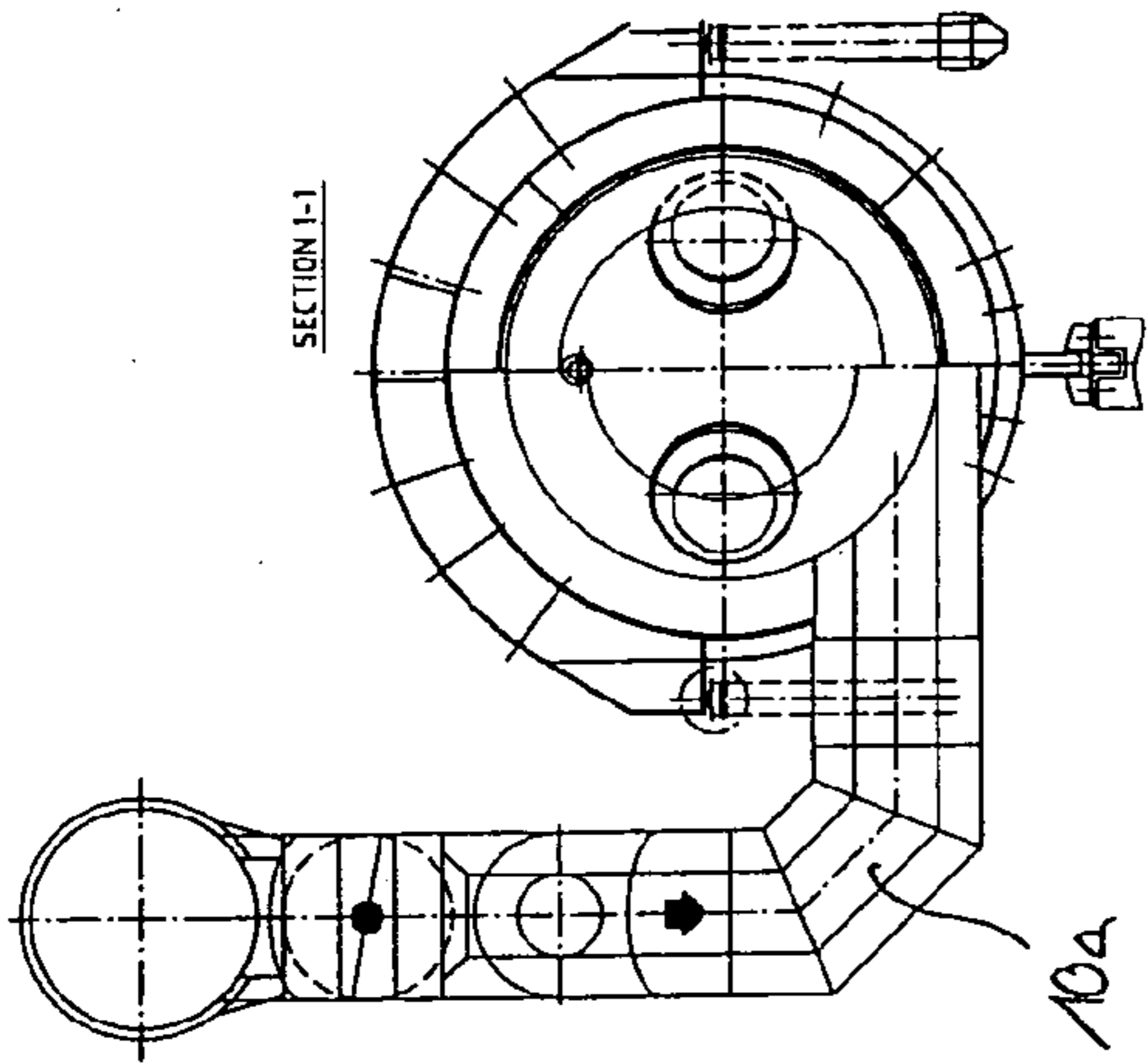


Fig. 4b

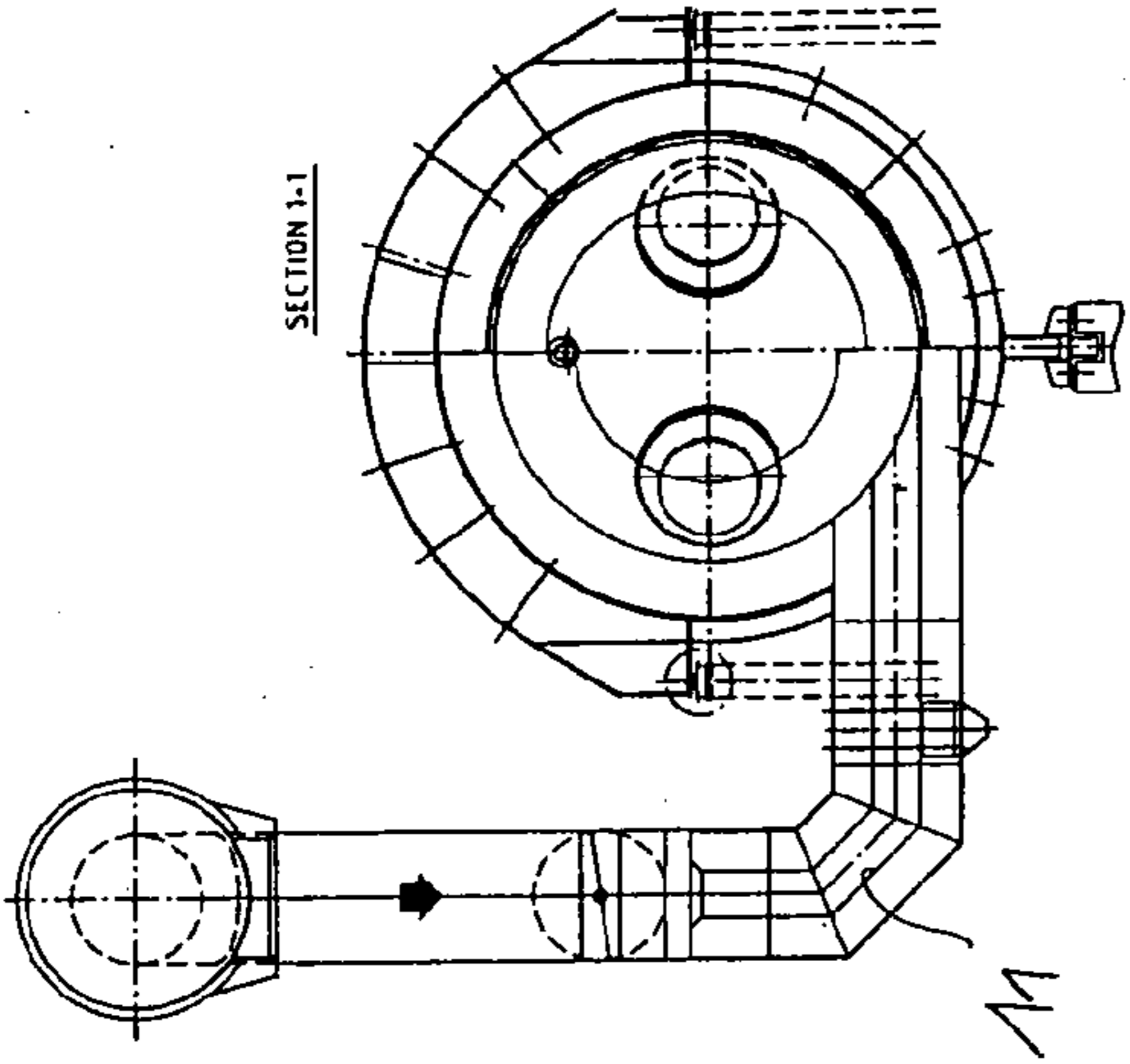


Fig. 4c

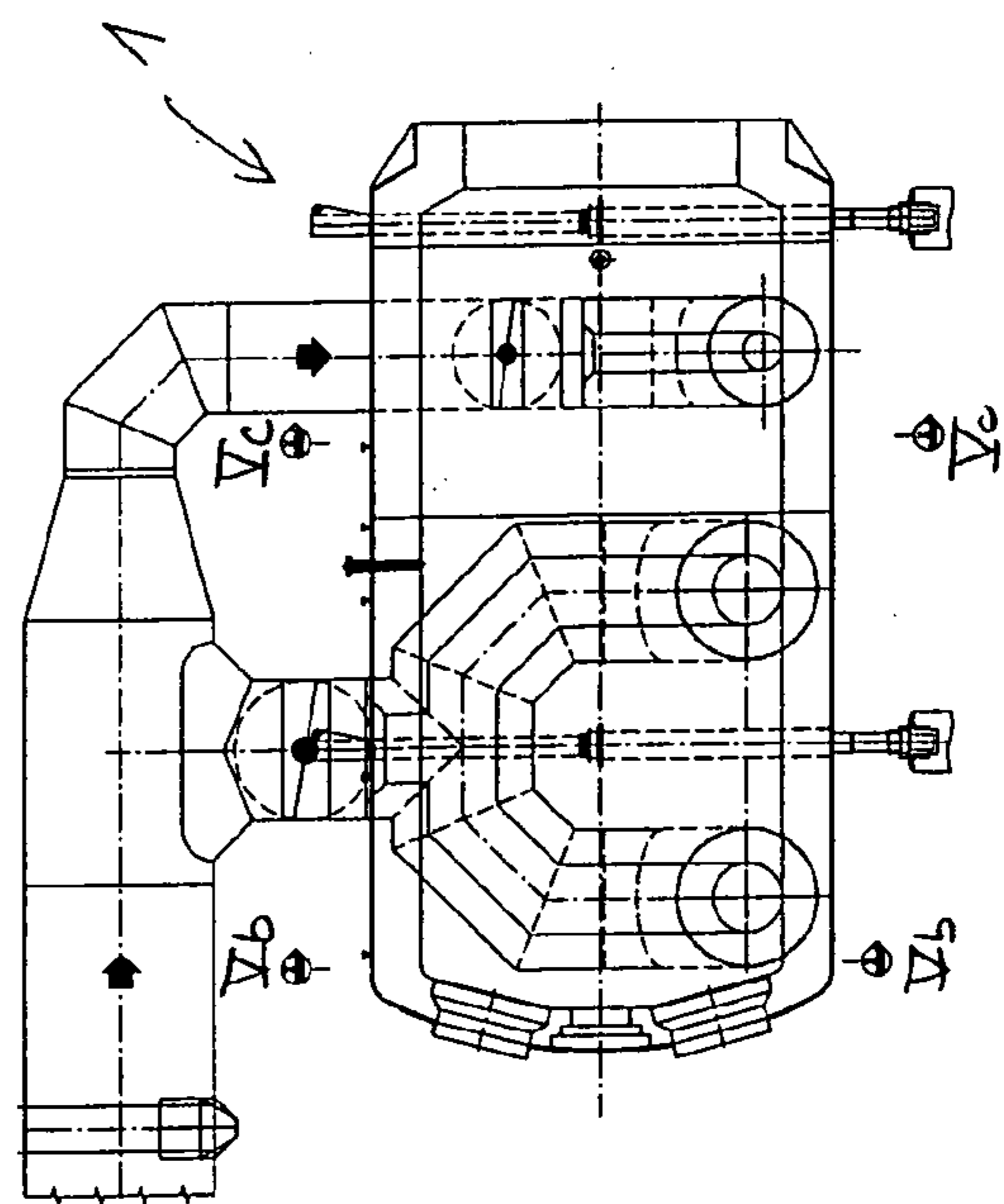


Fig. 5a

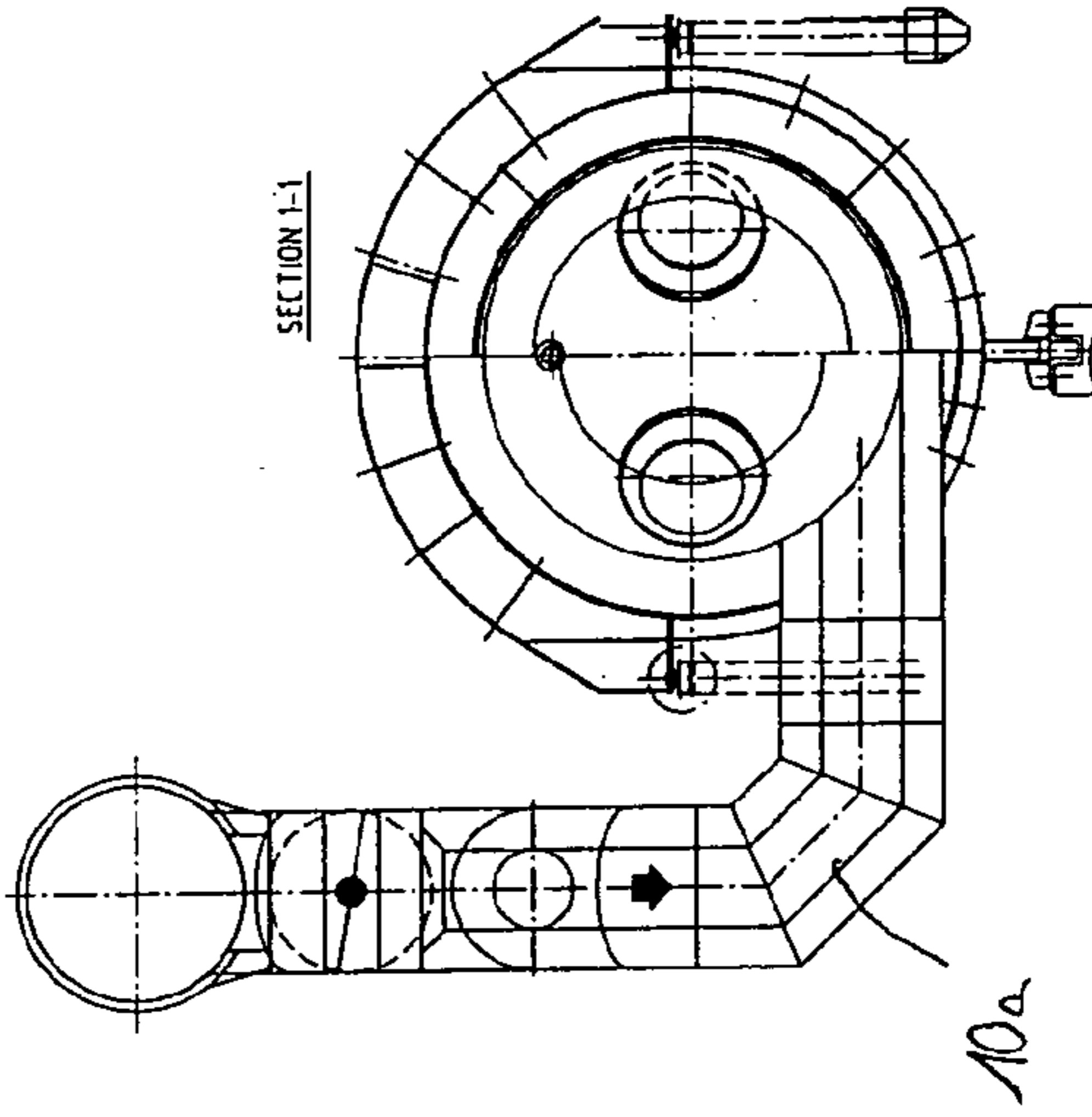


Fig. 5b

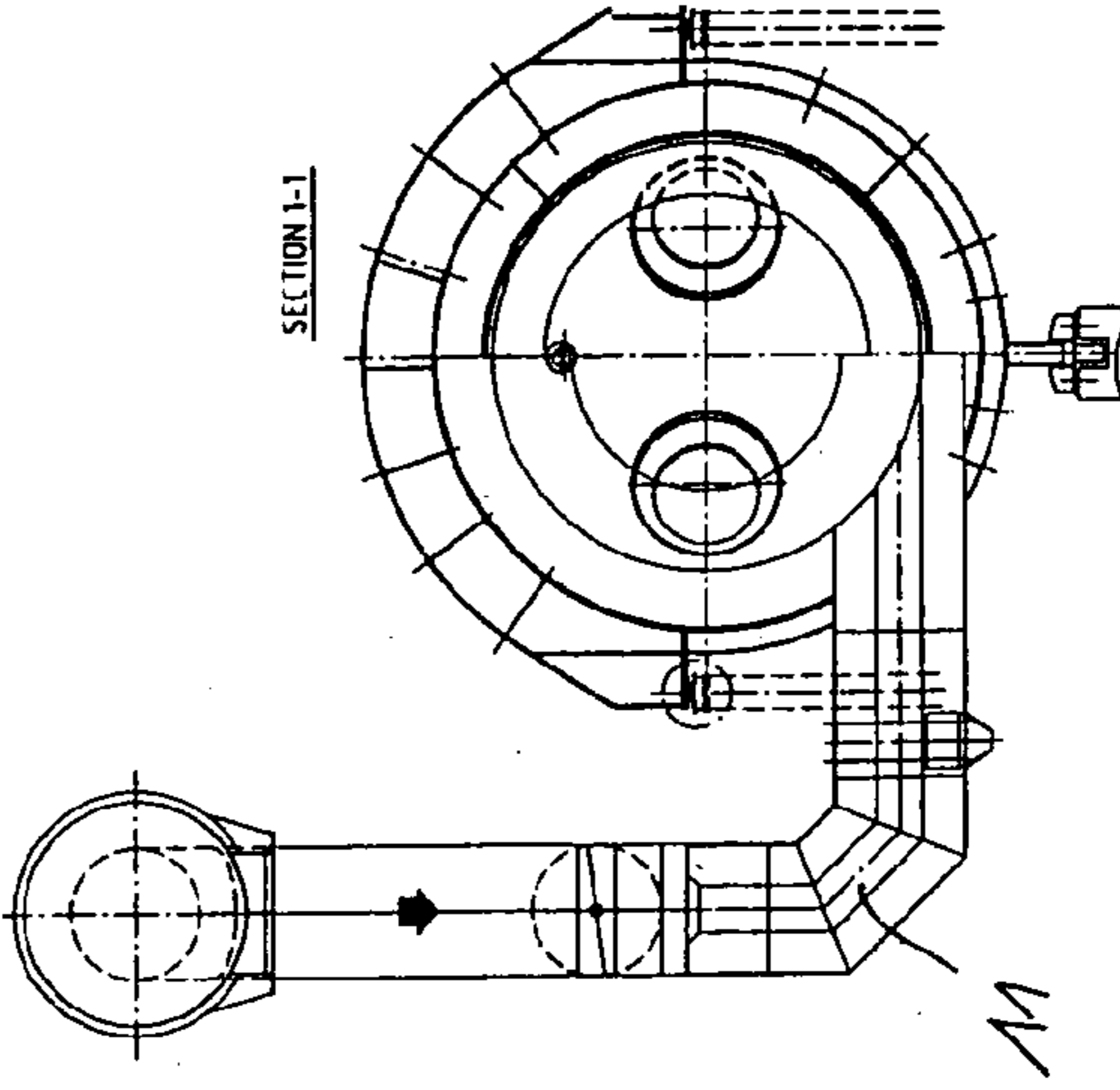


Fig. 5c

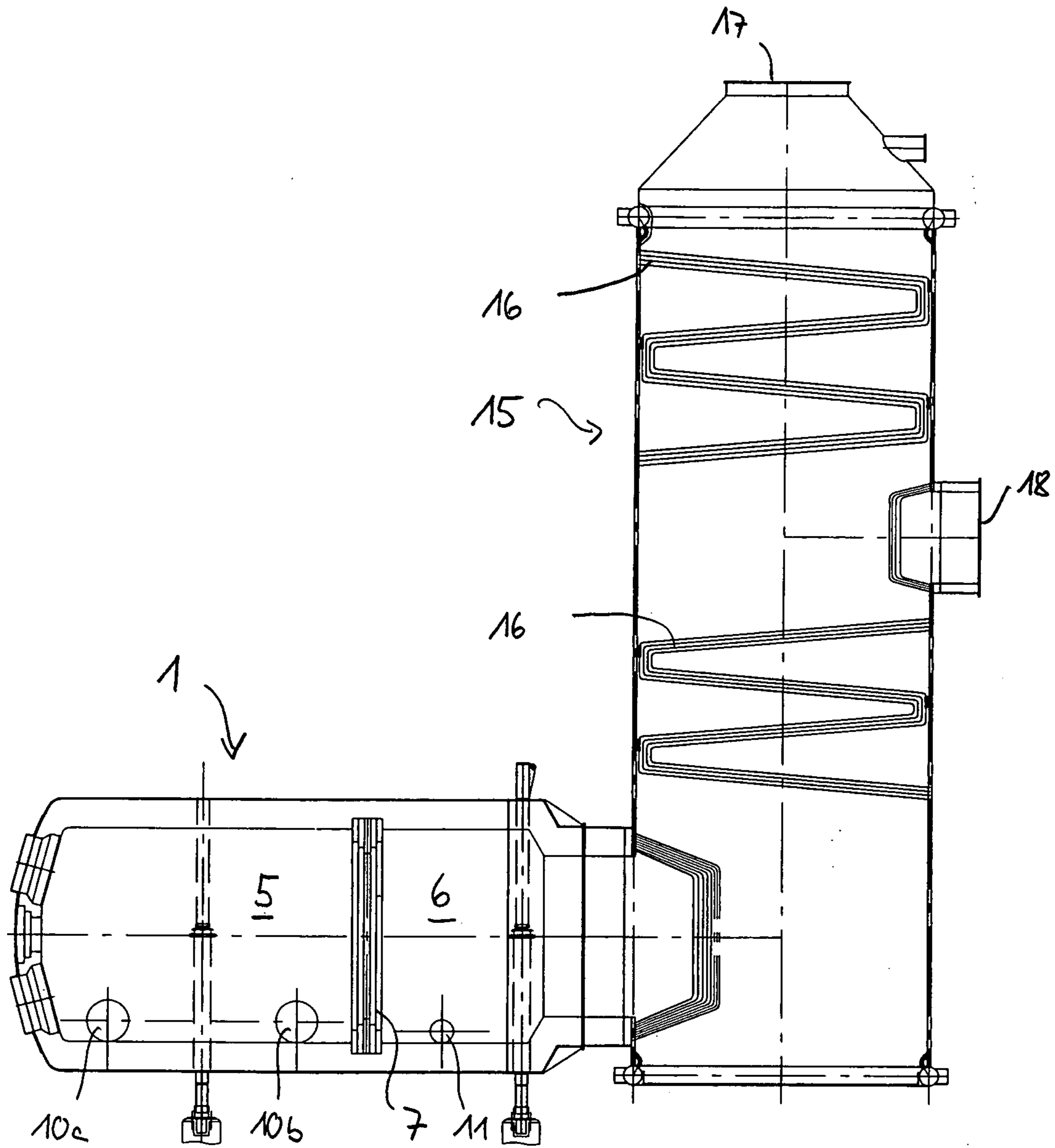


Fig. 6

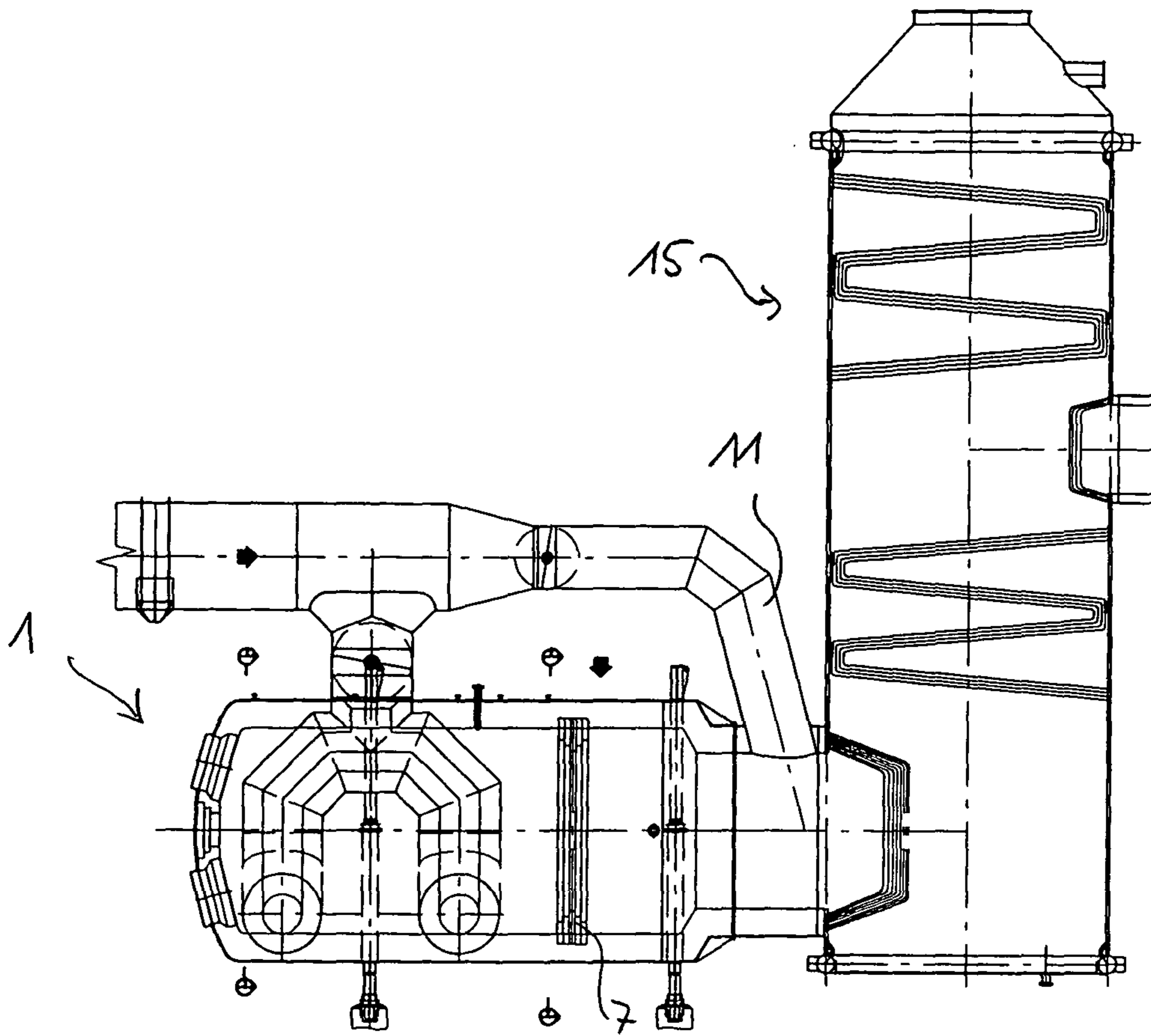


Fig. 7

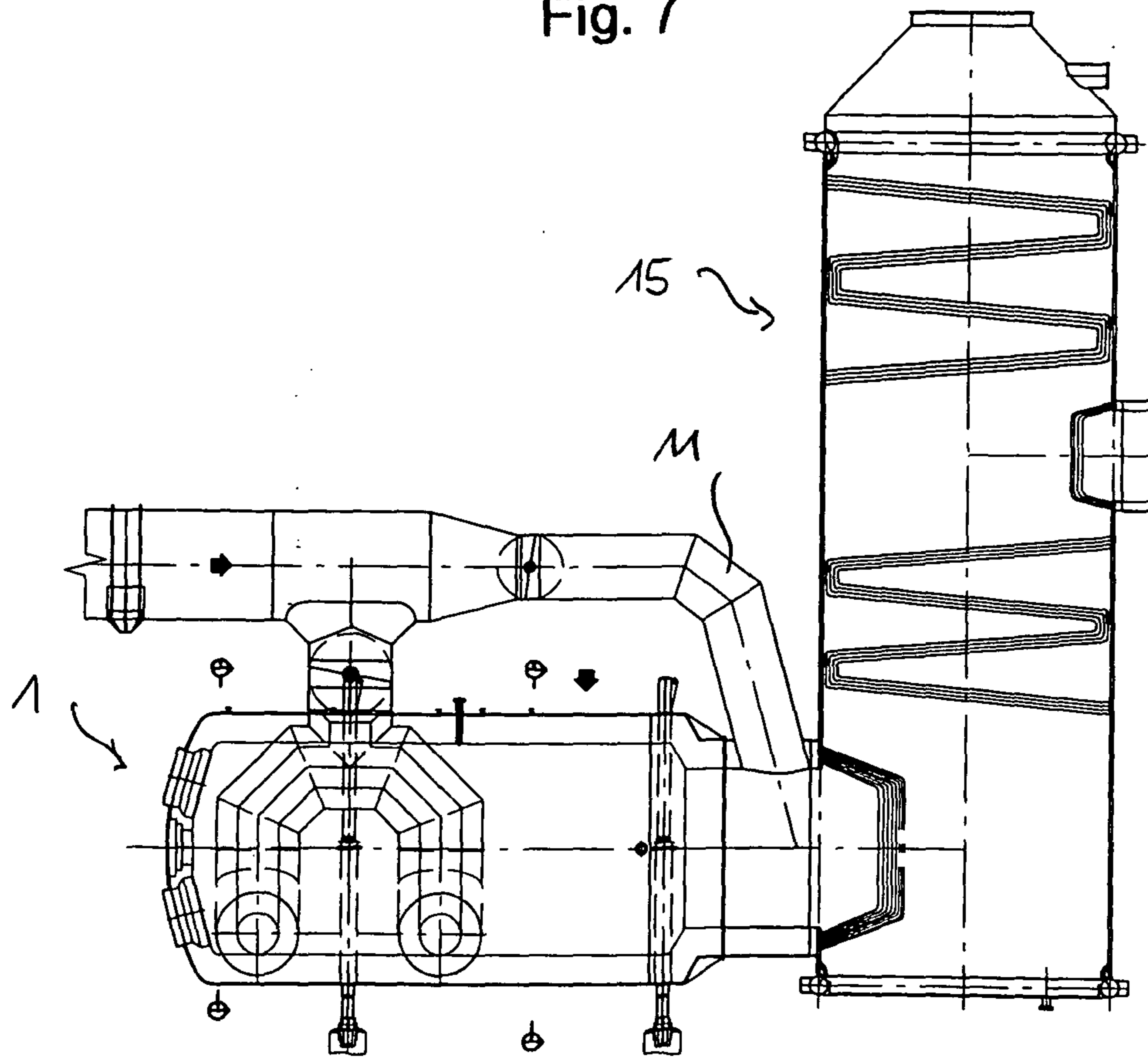


Fig. 8

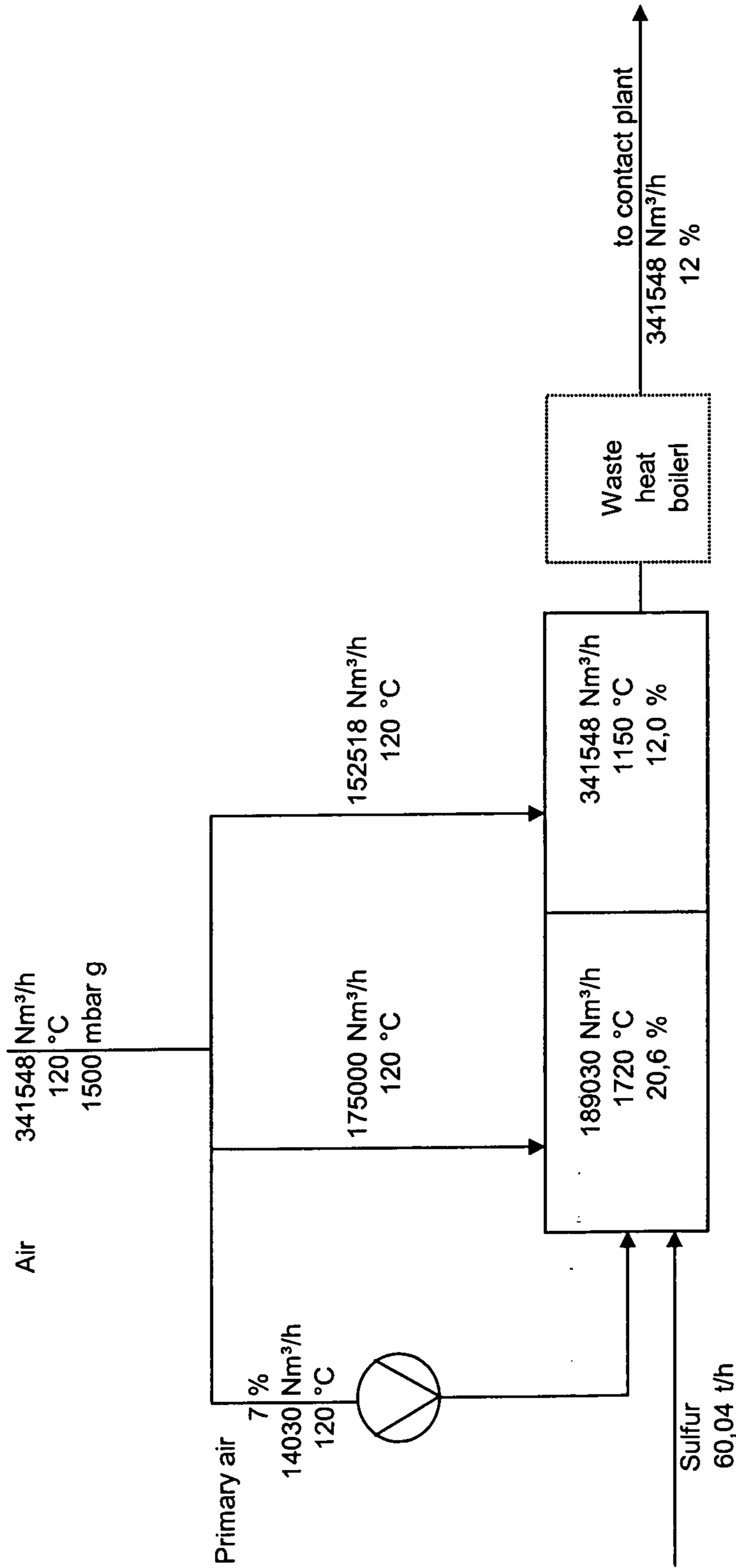


Fig. 9

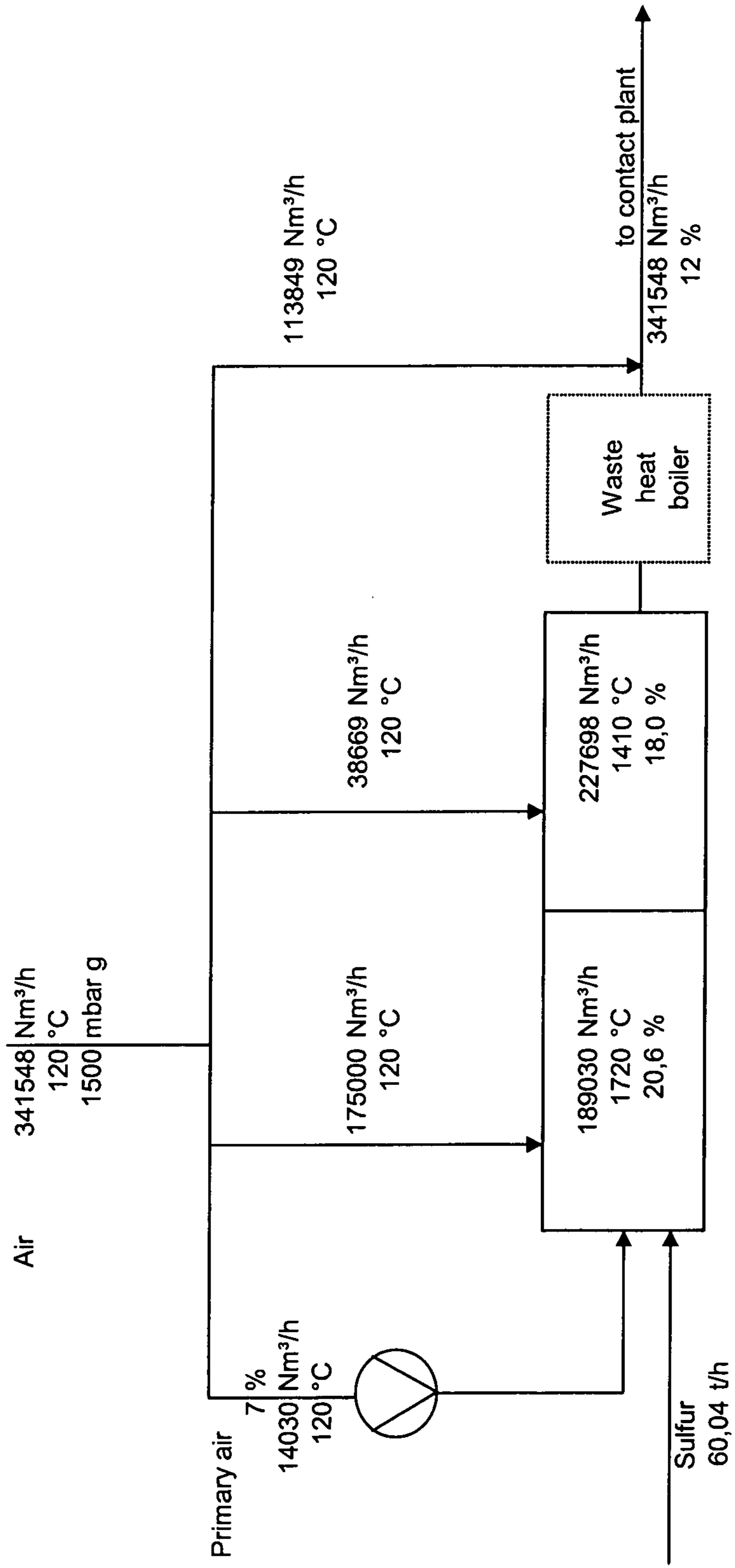


Fig. 10

